DOCUMENT RESUME

ED 287 735 SE 048 699

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TITLE Differences in Students' Perceptions of Their High School Biology and Chemistry Classes over the Course of a School Year.
PUB DATE Apr 87
NOTE 16p.; Paper presented at the Annual Meeting of the Eastern Psychological Association (Washington, DC, April 9-12, 1987).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Biology; *Chemistry; *Creative Thinking; *Divergent Thinking; High Schools; Logical Thinking; Problem Solving; Recall (Psychology); Science Education; Science Instruction; *Scientific Attitudes; *Secondary School Science

ABSTRACT

The purpose of this study was to describe student perceptions within high school classes in biology and chemistry over the course of a school year. The sample consisted of 435 high school college preparatory science students who were enrolled in 44 different biology and chemistry classes in central New York State. Measurements of attitude toward science and perceptions of the classroom environment were made with 33 Likert-type items drawn from other instruments. The results indicated that science attitudes become worse during the school year. According to the perceptions of the students, two thinking variables, creative exploration and logical thinking, decreased during the school year. Creative exploration, which involves divergent thinking, was significantly different between chemistry student's perceptions and the biology students' perceptions, with chemistry students indicating that lower levels of creative exploration occur in those classes. The results also indicated that many of the correct answers in chemistry may be obtained by using logical thinking and problem solving techniques, whereas biology students quickly learn that success is obtained by remembering large amounts of information. (TW)

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DIFFERENCES IN STUDENTS' PERCEPTIONS OF THEIR HIGH SCHOOL BIOLOGY AND CHEMISTRY CLASSES OVER THE COURSE OF A SCHOOL YEAR

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Washington, D.C.
April 9 - 12, 1987

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DIFFERENCES IN STUDENTS' PERCEPTIONS OF THE HIGH SCHOOL BIOLOGY AND CHEMISTRY CLASSES OVER THE COURSE OF A SCHOOL YEAR

The purpose of this analysis was to describe student perceptions within high school classes in biology and chemistry over the course of a school year. The data reported in this paper were collected as part of a project on the improvement of high school science instruction. The project involved 44 science teachers of college preparatory biology and chemistry classes (Schell, et.al., 1986).

Theoretical Basis

Aside from the obvious differences in subject matter, most educators and researchers tend to regard high school science courses as similar to one another. They tend to speak of science teachers and science students as if they constituted relatively homogeneous groups of individuals and of science instruction as if it represented a distinct set of instructional strategies. While the content of earth science, biology, chemistry, and physics is known to be different, the process transactions are typically regarded as similar.

There is, however, some reason to doubt the similarity of process in different high school science courses. As a part of a large scale project to assess the effect of increased wait time and supportive intervention on high school chemistry and biology classes, researchers analyzed hundreds of classroom tape recordings. As they began the analysis process the research team was surprised to find that there appeared to be different

characteristics of classroom interaction between the disciplines of biology and chemistry. This leads to the question: Are there qualitative differences in student perceptions of interaction patterns for biology and chemistry classes?

The purpose was to determine the extent and nature of the differences between high school biology and chemistry classes based on a direct measure of students' perceptions over time.

Procedure

The sample consisted of the responses of 435 high school college preparatory science students who were enrolled in 44 different biology and chemistry classes. Only those who completed all items at both testings were included in the analysis. The classrooms were located in 15 different school districts in central New York State.

Data were collected with a questionnaire distributed during a regular classroom period that students returned in a sealed envelope to assure confidentiality. The return rate was in excess of 75%. The data used in this analysis were from both the pretest and posttest of the larger study that had been gathered in order to assess changes that took place in attitudes toward and perceptions of the classroom environment between the beginning and the end of the school year.

Measurements of attitude toward science and perception of the classroom environment were made with 33 Likert-type items drawn in part from an attitude toward science scale developed by

Talton and Simpson (1985), a scale developed by Hasan (1985), and from the Classroom Activities Questionnaire (CAQ). The CAQ provides a measure of student perceptions of their classroom environment (Steele, Walberg, & Kerins, 1971; Steele, Walberg, & House, 1974).

Perception-attitude items from both the pretest and posttest administrations of the questionnaire were subjected to a principal components analysis. Components with associated eigenvalues greater than 1.0 were retained, rotated to the varimax criterion, and used to form component scores (Table 1). The five components were identified as: science attitude (SA), creative exploration (CE), logical thinking (LT), student involvement (IN), and remembering information (RI).

The data were analyzed with a two-way multivariate analysis of variance (MANOVA) in order to explore the differences between perception measures. There were two main effects -- class and time. Class [BIOLOGY or CHEMISTRY] produced a between-subject effect and time [BEGINNING or END of year] a within-subjects effect. The analysis was carried out with an SPSS/PC-X computer package (Norusis, 1986).

Table 1

Description of the Perception and Attitude Components in Terms of Sample Items with High Loadings

Component	Sample Item
Science attitude [SA]	I really like science.
Creative exploration [CE]	Inventing, designing, composing, and creating are major activities.
Logical thinking [LT]	Great importance is placed on logical thinking.
Student involvement [IN]	There is little opportunity for student participation in discussions.
Remembering information [RI]	Remembering or knowing information is the student's main job.

Results

The mean attitude and perception scores by course and time are presented in Table 2. With the use of the Wilks' criterion, the combined dependent variables (DVs) were significantly affected by both course, $F(5,429)=8.482$, $p=<0.001$, and time, $F(5,429)=5.376$, $p<0.001$ (Table 3).

Table 2

Mean Values of the Dependent Variables by Class (subject studied) and Time of Testing

	BIOLOGY		CHEMISTRY	
VARIABLE	PRE	POST	PRE	POST
Perceptions				
SA	-0.023	-0.134	0.109	-0.050
CE	0.167	0.032	-0.183	-0.258
LT	-0.023	-0.048	0.156	-0.044
IN	0.110	0.125	0.023	-0.145
RI	0.168	0.142	-0.244	-0.150

Table 3

Results of the Multivariate Analysis of Variance of the Main Effects of Class (subject studied) and Time of Testing and Their Interaction on Perceptions

Source of variation	Lambda	F	df	p
Between-subject effect				
COURSE	0.91004	8.482	5,429	<0.001
CONSTANT	0.99098	0.781	5,429	0.564
Within-subject effects				
COURSE X TIME	0.98365	1.426	5,429	0.214
TIME	0.94104	5.376	5,429	<0.001

To investigate the effects of each main effect and interaction on the individual DVs, a stepdown analysis was performed on the basis of an *a priori* ordering of the importance of the DVs. Thus, each DV was analyzed, in turn, with higher-priority DVs treated as covariates and with the highest-priority DV tested in a univariate ANOVA.

Two of the variables had statistically significant stepdown *F*-ratios indicating their contribution to the differentiation of biology and chemistry students over time (Table 4).

Table 4

Univariate and Discriminant Analyses of the Differences Between Students By Class

	F-test		Discriminant Function	
Total across time	*Univariate*	*Stepdown*	*d*	*r*
Perceptions				
SA	1.557	1.557	-.214	-.191
CE	15.101***	14.985***	.607	.594
LT	1.270	1.698	-.125	-.172
IN	3.899*	2.820	.321	.302
RI	19.388***	20.246***	.713	.673

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

After correction for the effect of previously entered variables, class members were differentiated by their level of creative exploration (CE) and remembering information (RI). With a cut-

off of 0.300 for interpretation, the correlations between the discriminating variables and the discriminant function indicated that biology students reported higher levels of remembering information (r = 0.673) and creative exploration (r = 0.594) than did chemistry students.

The results of the univariate tests and discriminant function analysis for the within-subjects main effect of time are presented in Table 5. The stepwise F-tests indicated that there

Table 5

Univariate and Discriminant Analyses of the Differences Between Students By Class Over Time

Difference between times	F-test		Discriminant Function	
	Univariate	Stepdown	d	r
Perceptions				
SA	11.339***	11.339**	-.659	-.647
CE	4.954*	5.319*	-.596	-.427
LT	4.906*	7.301**	-.539	-.425
IN	1.831	1.841	-.264	-.260
RI	0.447	0.684	.165	.128

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

were significant changes in perceived level of attitude toward science, creative exploration, and logical thinking over time. Correlations between the discriminating variables and the

discriminant function indicated that the perceived levels of science attitude (r = -0.647), creative exploration (r = -0.427), and logical thinking (r = -0.425) declined in both classes over the course of the school year.

The changes in variables over time are shown graphically in Figures 1 and 2 (see Appendix). Biology students are more likely to describe their classroom environment as one in which they must learn and remember considerable amounts of new information. More than chemistry students, biology students believe they participate in discussions that develop new ideas. Students in both classes reported a general decline in logical and divergent cognitive activities and in their attitude toward science as the school year progresses. The course by time interaction was not significant; students in both courses reported changes of a pattern and magnitude such that their position relative to one another remained similar.

Conclusions

Two major types of differences were found in the student perception variables: those that relate to time and those that relate to the course being taught. Those that were affected by time included science attitude and the amount of perceived thinking involved with both biology and chemistry students. Science attitudes became worse during the school year. This type of finding has been noted in many other studies. Although it is not surprising, it is disappointing to see students liking

biology or chemistry less as compared to their feelings at the beginning of the semester. Although it would have been encouraging to see the student attitudes become more favorable, having them remain at the same level would be an improvement over what actually does happen in many instances.

According to the perceptions of the students, two thinking variables, creative exploration and logical thinking, decreased during the school year. It appeared that the students did not see the disciplines of biology and chemistry as being as open to multiple answers or as logical as they had thought it would be early in the semester. Again, it would have been encouraging to see these two factors remain at the level that was perceived near the beginning of the academic year.

The differences that were found between perceptions of chemistry and biology classes are also intriguing. Creative exploration, which involves divergent thinking, was significantly different between chemistry students' perceptions and the biology students' perceptions with chemistry students indicating that lower levels of creative exploration occur in those classes. Our impression, from initial inspection of our large data base on classroom questioning, is that fewer divergent questions are posed by chemistry teachers. It may be that there is very little provision made in chemistry for students to explore alternative methods for solving problems and thinking about science.

The other significant difference between biology and chemistry occurs with the remembering information factor. Again,

this was not surprising. Whereas many of the correct answers in chemistry may be obtained by using logical thinking and problem solving techniques, the terminology load in biology class is forbidding. Students quickly learn that success is obtained by remembering large amounts of information. Until this memorization load can be reduced, students' perceptions of biology are likely to remain as little more than factual memorization.

Implications

In general, educators and researchers need to be more concerned than they have been in the past about structural as well as cognitive differences between science courses. Not only is the subject matter different, but the manner in which the students perceive and interact with the teacher and with each other is different. The idea of homogeneous "science students" may be as misleading as the idea of teaching a single "science" in high school.

ACKNOWLEDGMENT

This research was supported in part by a grant from the National Science Foundation (Contract No. MDR84-70215). The opinions expressed herein are those of the authors and do not necessarily reflect the position, policy, or endorsement of the National Science Foundation.

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Appendix

Changes in Students' Perceptions over Time

FIGURE 1:

DIFFERENCES IN MEAN SCORES OVER TIME IN BIOLOGY CLASSES

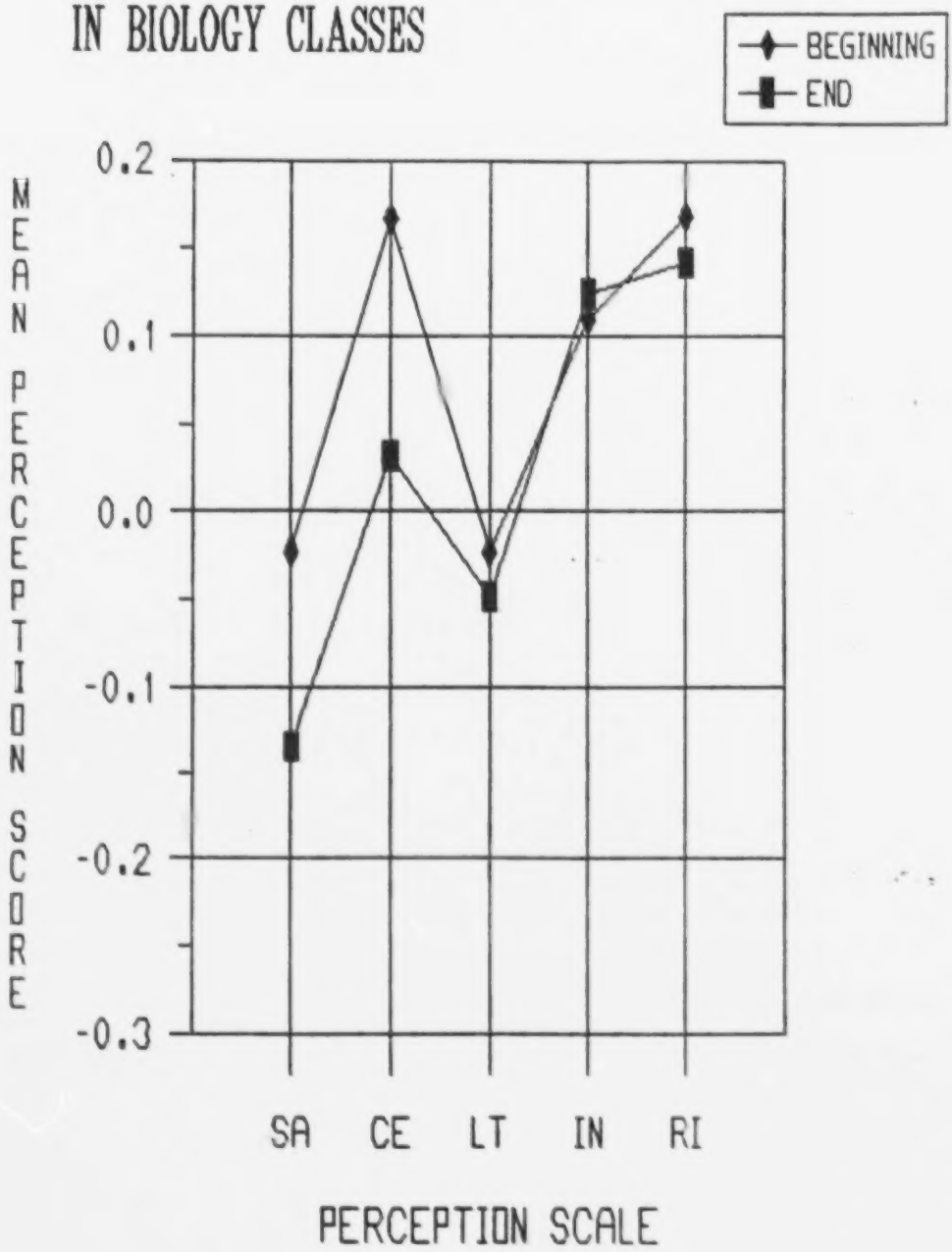

FIGURE 2:

DIFFERENCES IN MEAN SCORES OVER TIME
IN CHEMISTRY CLASSES